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MOLA TOPOGRAPHIC VARIATIONS ALONG THE CRUSTAL DICHOTOMY BOUNDARY ZONE IN EASTERN AND WESTERN MARS H. Frey[1], S. Sakimoto[2], and J. Roark[3], [1]Geodynamics Branch, Goddard Space Flight Center, Greenbelt, MD 20771, frey@denali.gsfc.nasa.gov, [2]USRA at the Geodynamics Branch, Goddard Space Flight Center, Greenbelt, MD 20771, sakimoto@denali.gsfc.nasa.gov, [3]Science Systems & Applications, Inc., Lanham, MD 20706, roark@denali.gsfc.nasa.gov.

Summary: The topographic character of the martian crustal dichotomy boundary zone changes along the boundary, as does the morphological character of the boundary itself. Overall the elevation change from lowland plains to cratered uplands has the character of a step function, but the magnitude of the step and the slope of the ramp in the transition zone between the two relatively flat surfaces is different in different areas. Especially prominent is the difference between the boundaries in Deuteronilus-Ismenius Lacus and in Tempe Terra: Total relief in the transition zone in central Tempe is significantly greater than that in most of the eastern boundary zone. The correlation of topography with changing morphological character and mapped geologic units suggests that different parts of the boundary had different modification histories, and, perhaps, different origins as well.

Introduction. MOLA data from the Aerobraking Hiatus (AH) and Science Phasing Operations (SPO) 1 and 2 provide good coverage over the northern hemisphere of Mars, espepcially for the crustal dichotomy boundary zone in both the Deuteronilus-Ismenius Lacus (DIL) and Tempe Terra (TT) regions. Based on AH data alone we were able to show that a significant topographic signature is closely associated with the distinct transition zone between cratered uplands and lowland plains in eastern Mars [1]. The topography of this transition zone (TZ) is well approximated by a step function or ramp between two relatively flat surfaces. The TZ regional slope (~1°) increases by 50-100 times over that in either the cratered highland terrain (~0.02°) or lowland smooth plains (<~0.01°). The size of the step within the TZ varies from 2-4 km in eastern Mars, while the overall maximum relief between the lowlands and cratered highlands (so far sampled, to about 20N) can be in excess of 6 km [1]. From the increased coverage provided by SPO passes, we see even greater TZ relief in TT than in DIL, as well as important changes in the topographic character along the boundary in both parts of Mars.

Figures 1a and 2a show MOLA passes in the TT and DIL regions of Mars. The character of the boundary zone between cratered highlands and lowland plains is quite different in the two regions. In TT the boundary zone is very narrow, and detached plateaus, mesas, individual large scale knobs and more widely distributed smaller scale knobby terrain are far less abundant than in eastern Mars. In DIL the transition zone is generally wider but also varies greatly in both width and in the nature and abundance of the features (knobs, mesas) which characterize this zone.

In Figures 1a and 2a the MOLA passes tend to cluster but the overall coverage is quite good. Passes which are spatially close tend to show the same general topographic character at moderate scales, differing only in the small scale details associated with individual craters, mesas and knobs. Because there are relatively discrete groups of passes, we selected a representative profile from each group in order to study possible variations in the regional topographic signature along the boundary. Figures 1b and 2b show these representative passes along with simple straight-line fits to the regional scale topography. These fits ignore craters, knobs, mesas and the like, and attempt to represent the overall surface trends at scales >~5° of latitude (>~200 km). In this representation we even ignore large basins such as the 400-600 km wide "MOLA Hole" (dashed lines, Figure 2b, pass 264), the discovery of which is describe elsewhere [2, 3]. The representative profiles are arranged top to bottom from west to east. DIL passes do not reach as far south of the TZ as do those in TT, so the regional trends in the cratered terrain are not so well characterized in eastern Mars.

There are obvious and significant changes in the regional elevation trends along the boundary in both regions. In Tempe (2a), elevation and relief across the narrow TZ are low at the E edge of the region (pass 456), and increase dramatically toward central TT where nearly 5 km of rise occurs in a 300 km wide zone (passes 454, 435). The TZ rise is also steeper here compared with that to the W and E. The highland terrain just south of the TZ rise peaks sharply then decreases in elevation further south. On either side of this central region the highland terrain tends to be flatter away from the boundary (W passes 26, 250,E passes 233, 345).

In Deuteronilus-Ismenius Lacus (2b) the cratered terrain is less peaked just south of the transition zone than in central TT. The highlands and lowlands away from the TZ are mostly flat. The rise through the TZ is greater and more abrupt in the central part of the region (passes 428, 264) than to the W (passes 407, 426, 445, 224) or the E (passes 209, 025, 211), but the change is not as dramatic as in TT. We also note that where the greater and more peaked relief occurs in Tempe there are younger (Hesperian) plains, small volcanoes and old (Noachian) fractured units [4], which are generally not present in the cratered terrain in eastern Mars [5] at the same distance from the dichotomy boundary.

The changing topographic (and morphological) character both along the dichotomy boundary zone and between these zones in eastern and western Mars, suggest different histories for the different parts of the boundary. This may include different origins or different modification processes in the different regions, or both.

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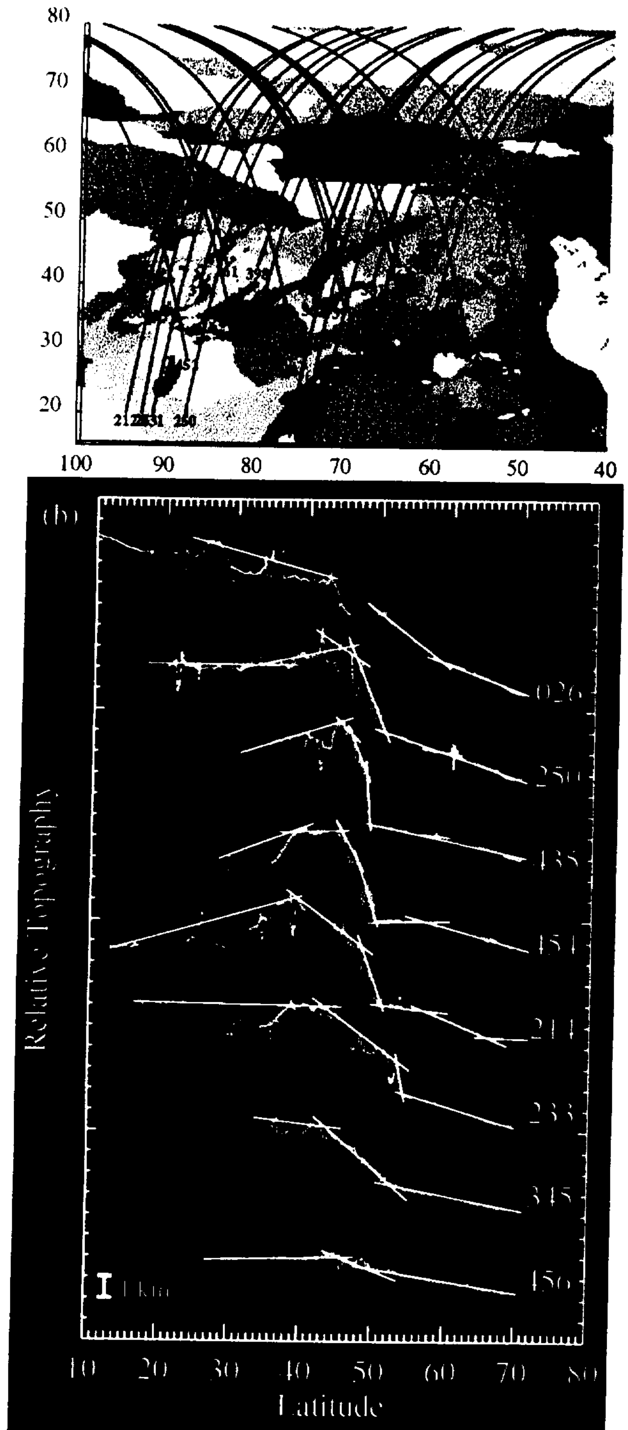

Figure 1: (a) MOLA passes across the crustal dichotomy boundary zone in Tempe Terra, superimposed on a simplified geologic map. (b) Elevation versus latitude for representative profiles from groups of passes shown in Figure 1a. Straight lines are approximate fits to regional trends.

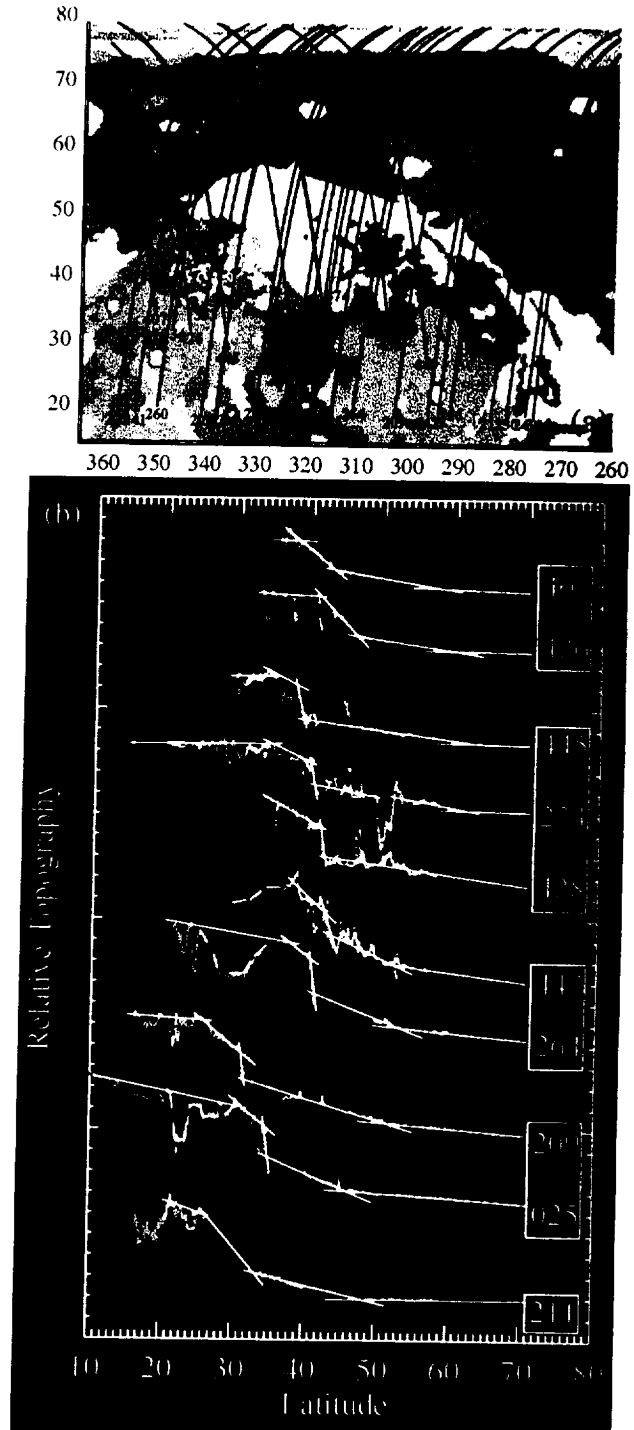

Figure 2: (a) MOLA passes across the crustal dichotomy boundary zone in the Deuteronilus-Ismenius Lacus region, superimposed on a simplified geologic map (b) Elevation versus latitude for representative profiles from groups of passes shown in Figure 2a. Straight lines are approximate fits to regional trends. Elevation and latitude ranges and scales the same as in Figure 1.

MOLA TOPOGRAPHIC STRUCTURE OF THE ISIDIS AND UTOPIA IMPACT BASINS. H. Frey[1], S. Sakimoto[2], and J. Roark[3], [1]Geodynamics Branch, Goddard Space Flight Center, Greenbelt, MD 20771, frey@denali.gsfc.nasa.gov, [2]USRA at the Geodynamics Branch, Goddard Space Flight Center, Greenbelt, MD 20771, sakimoto@denali.gsfc.nasa.gov, [3]Science Systems & Applications, Inc., Lanham, MD 20706, roark@denali.gsfc.nasa.gov.

Summary. MOLA data from the Aerobraking Hiatus and Science Phasing Operations (SPO) 1 and 2 provide good coverage of the Utopia and northern Isidis Basins. Gridded data show the Utopia Basin to be far more symmetric and bowl-like than was suggested by previous USGS topographic data, consistent with McGill's [1] interpretation of an ancient impact basin centered near 48N, 240W. Higher than average elevation occurs in polar terrain where the outer ring is expected to lie, raising the possibility that some polar elevation may not be entirely due to ice. For the Isidis Basin we find a center and inner ring diameter derived from concentric fits to slope breaks in a MOLA profile that are indistinguishable from those previously reported by Schultz and Frey [2] based on imagery alone. Less complete passes which cross the location of proposed but not visible Isidis rings in the buried NE section of the basin show little relief despite good coverage by MOLA. These results suggest MOLA topography can be used to help constrain the location and structure of major impact basins, perhaps also including basin diameter.

Isidis Basin. We previously described how fitting concentric circles to matching slope breaks on opposite sides of MOLA pass 34 through Isidis allowed us to determine the basin center and inner ring diameter [3, 4]. Our values were indistinuishable from those determined from photogeology alone by Schultz and Frey [2]. Figure 1 shows additional SPO passes. In the NW quadrant the peak elevation associated with the rugged rim material lies between the rings mapped by [2]. A "topographic" ring through this peak has a diameter of ~ 1500 km, close to that proposed by Pike and Spudis [5] for the "main" ring of Isidis. Toward the NE quadrant where the rugged basin rim is not visible, the elevated topography disappears as the terrain becomes smoother. Whether it is buried by the younger plains or simply missing entirely, there is little topographic expression to mark the expected location of the basin rim in this region.

Utopia Basin. Figure 2 shows contoured topography of the Utopia Basin region from the USGS DEM (top) and from MOLA data combined with low resolution spherical harmonic representation of occultation-derived heights [6] (bottom). The basin is much more symmetric and bowl-like than USGS data previously suggested. The lowest elevation is near the basin center, and the elevation contours have strong circular symmetry. The MOLA topography is very consistent with McGill's [1] suggestion of a buried impact basin centered near 48N, 240W. His inner ring (D~3300 km) closely follows the -4 km contour over more than 50% of its circumference [4]. The outer and perhaps main [7] ring (D~4700 km) lies in part along the crustal dichotomy boundary zone where relatively abrupt increases in elevation [8] may mark the rim of the impact basin.

Selected profiles which cross the Utopia rings are shown in Figure 3. The inner ring has little or no topographic relief, but minor slope breaks do occur in some passes at the expected locations. An obvious increase in elevation occurs at the expected location of the outer ring where it lies along the dichotomy boundary. In passes 247 and 36 there are two distinct bumps, one at the expected location of the outer ring, the second to the S where the dichotomy boundary occurs. In both of these passes the topography at the ring location is the same: a rounded, ~1 km bump about 150-200 km across. The outer ring also passes through the north polar region (Figure 2), which near the pole rises some 3 km above the surrounding plains [9]. From the northerly passes in Figure 3 it is clear that elevations are highest in these regions at the predicted outer ring locations. It may be that some of the elevation of the polar terrain is due to the Utopia impact rim and not entirely due to ice. If true, this would reduce estimates of the total stored volatile inventory by comparison with those assuming the entire thickness is ice [9].

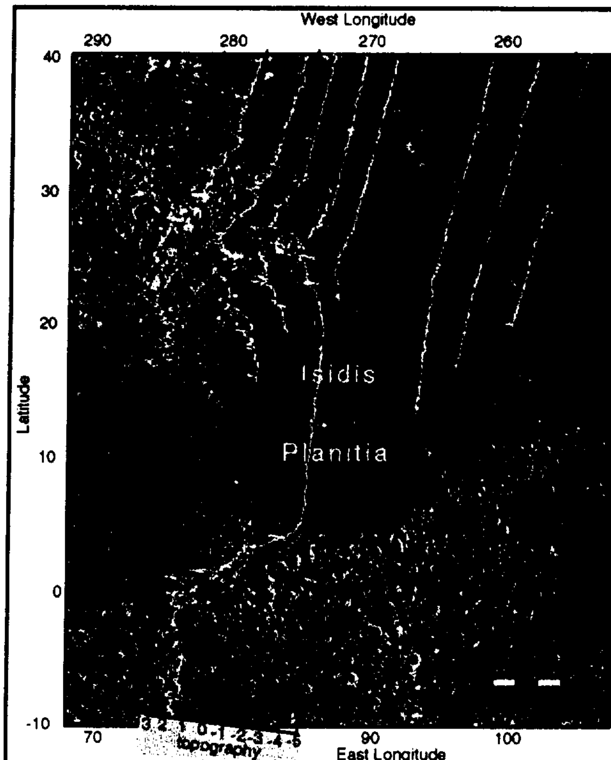

Figure 1: MOLA passes over the Isidis Basin. Only one pass (34) crosses the entire basin and shows the difference between the very high southern and lower northern rim. Note the lack of any signficant elevation in the NE quadrant where the rim is either missing or buried by younger plains.

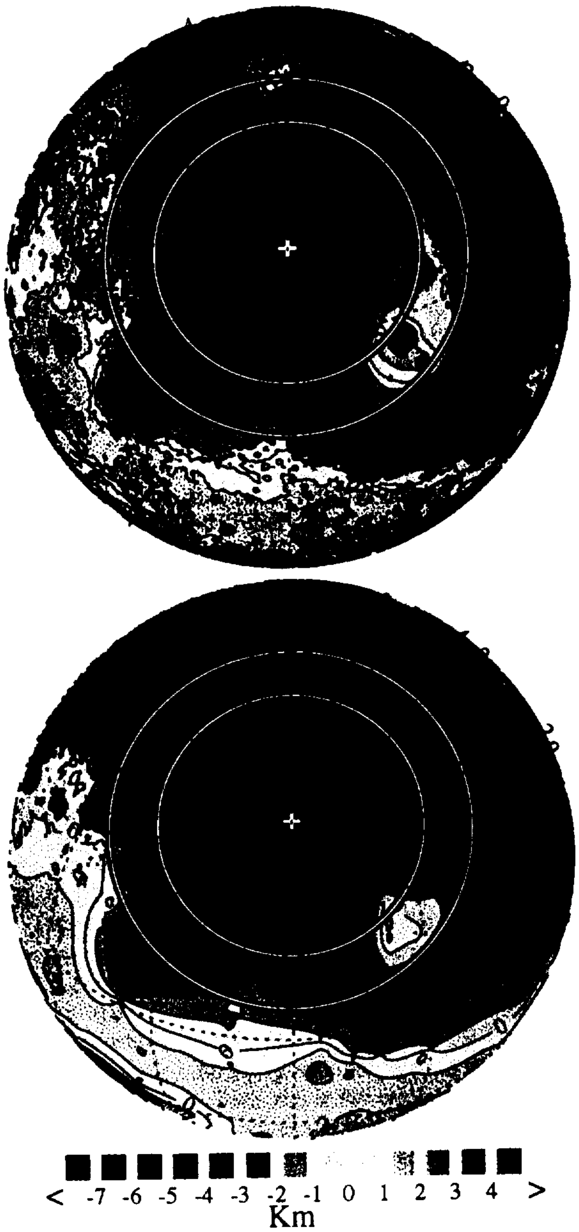

Figure 2: Gridded topographic data from USGS and from a gridded data set (Neuman, personal communication) that combines MOLA data from 30N and higher with a low resolution spherical harmonic representation of occultation-derived heights [6] (30N and south). The MOLA data in this grid includes cross-over adjustments to the orbits (Neumann, personal communication). There is a zero-level difference between the USGS and MOLA data sets due to different reference levels.

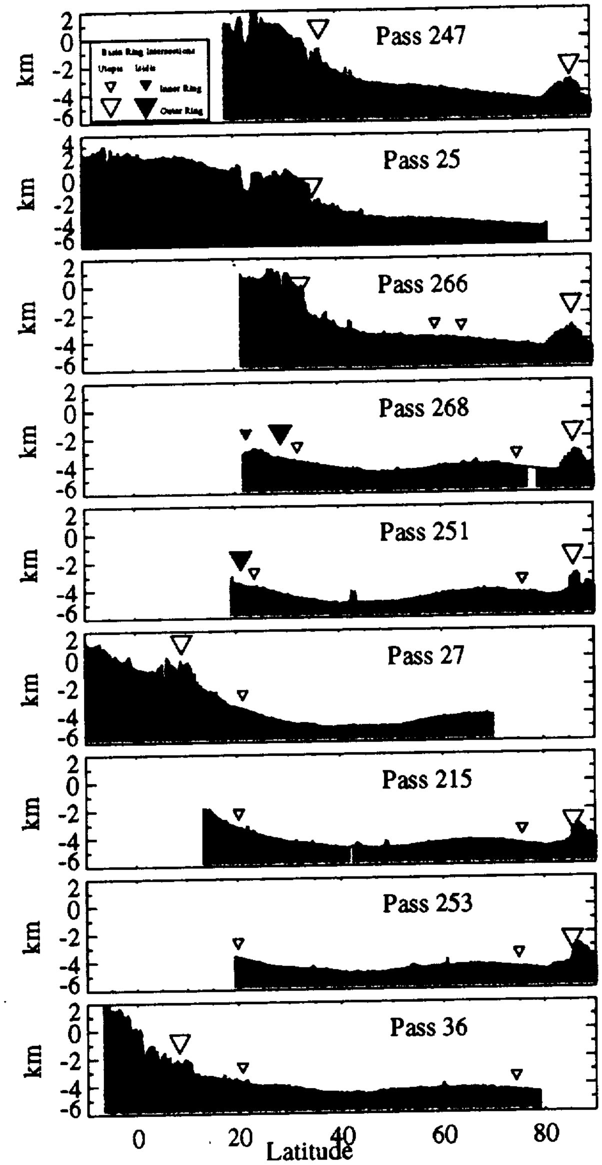

Figure 3: Selected MOLA profiles showing the locations where the inner (small inverted triangles) and outer (large inverted triangles) rings are expected to lie. Note the topography associated with the outer ring in passes 247 and 36 is separate from that associated with the crustal dichotomy boundary zone. Also note the high elevation in the north polar region at the expected location of the outer ring.

References. [1] McGill, G. E. , JGR 95, 2753-2759, 1989. [2] Schultz, R. A. and H. Frey, JGR 95, 14,175-14,189, 1990. [3] Pike, R. J. and P. D. Spudis, Earth, Moon, Planets 39, 129-194, 1987. [4] Frey, H. et al., Lunar Planet. Sci. XXIX, 1998. [5] Frey, H. et al., submitted to JGR, 1999. [6] Smith, D. E. and M. T. Zuber, Science 271, 184-188, 1996. [7] Schultz, R. A. and H. V. Frey, JGR 95, 14,175-14,189, 1990. [8] Frey et al., submitted to JGR, 1999. [9] Zuber, M. T. et al., Science 282, 2053-2060, 1998.